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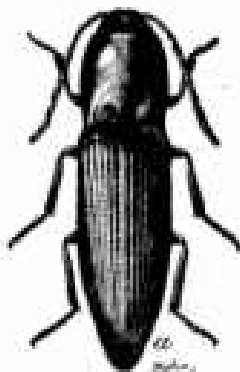
THE CORN AND COTTON WIREWORM¹ IN ITS RELATION TO CEREAL AND FORAGE CROPS, WITH CONTROL MEASURES.

By EDMUND H. GIBSON,

Scientific Assistant, Cereal and Forage Insect Investigations.

INTRODUCTION.

During the three years which have elapsed since the investigation of the corn and cotton wireworm (fig. 1, *b*) was begun there have been constant requests by farmers and others for remedial measures, and it is in answer to these requests that the present paper has been prepared. The injury, as in the case with other wireworms, is caused by the feeding of the worm-like young or larvae of slender beetles, known as "click beetles" or "snapping beetles," upon the roots, sprouts,



and underground stems of plants which are thereby weakened and stunted or killed.

EXTENT OF DAMAGE BY THE CORN AND COTTON WIREWORM.

These wireworms have been known totally to destroy corn throughout fields of large acre-



FIG. 1.—The corn and cotton wireworm: *a*, Adult, or beetle; *b*, larva, or wireworm. Much enlarged. (Hyslop.)

age. However, this is not usually the case and the attack is most frequently concentrated in "spots" scattered throughout the field, the plants in these spots being wholly destroyed. In other parts of the field there may be slight injury as shown by the dwarfed ap-

¹ *Hortistonotus uhleri* Horn; order Coleoptera, family Elateridae.

NOTE.—The object of this bulletin is to set forth in a popular form what is known of the habits of the destructive corn and cotton wireworm, in order that farmers and planters may more effectively carry out control measures and be able better to handle infested areas, that the injury may be reduced to a minimum.

pearance of the plants, which may later produce 50 per cent or more of a normal yield.

The wireworms are ravenous feeders, often cutting off all the roots of a plant. They are especially destructive during the two months before they transform to adults. A single half-grown wireworm is capable of killing a young corn sprout and severely injuring a plant from 6 to 8 inches in height. Therefore it can be seen that when there is a concentrated attack by many wireworms in one hill the plants have but small chance of surviving.

DESCRIPTION OF THE INSECT IN ITS DIFFERENT STAGES.

The parent of the corn and cotton wireworm (fig. 1, *a*) is a small dark brown click-beetle, or "snapping beetle," measuring about one-fourth of an inch in length. The eggs (fig. 2) laid by this beetle are white and nearly round; when first deposited they are translucent, but in a day or two become opaque. The young wireworms, or larvae, after hatching from the eggs are minute, measuring from an eighth to three-sixteenths of an inch in length. When from half to full grown (fig. 1, *b*) they may be described as "soft, membranous, and elongate."

The body, which is usually white, is apparently composed of 26 segments, or joints, every third segment being swollen. The last segment is simply pointed. The head, which is yellow, is long and slender, and has a pair of prominent, dark brown jaws. When full grown these larvae measure about an inch in length and are but slightly thicker than pack thread. The pupae (fig. 3), to which the larvae change before becoming adult beetles, have the same general color as the larvae and are about five-sixteenths of an inch long and nearly an eighth of an inch thick. Each pupa occurs in a small earthen chamber constructed by the larva.

All stages of the insect are spent in the ground except the adult or beetle, which only enters it at the time of egg deposition.

There are a number of other species of wireworms which are often found associated with this wireworm about the roots of corn and others of its food plants. The corn and cotton wireworm can be easily distinguished from these, however, by its light creamy color and threadlike form, as most other wireworms are stouter and usually either reddish or brownish.

WHERE THE INSECT OCCURS.

Reports show that the corn and cotton wireworm has been destructive in the Carolinas, Illinois, Missouri, Arkansas, and Missis-

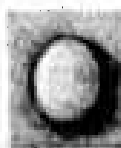


FIG. 2.—Egg of the corn and cotton wireworm. Much enlarged. (Original.)



FIG. 3.—Pupa, or resting stage, of the corn and cotton wireworm. Much enlarged. (Original.)

issippi. This would indicate a wide distribution, probably a wider one than the mere records reveal, and it is possible that the species may occur throughout the entire eastern half of the United States. Its occurrence is closely related to the distribution of soils of light sandy type, as it is known that the immature stages exist only in such soils. Occasionally an adult has been collected several miles from sandy locations, but its presence there was more than likely due to its own flight from the field of its origin. In some localities this species is referred to as the "sandy-spot wireworm."

PLANTS ATTACKED.

Cotton and corn constitute the principal food plants of this wireworm, and of the cereal and forage crops in the South the greatest damage is done each year to corn. The wireworms, besides feeding upon the roots of corn and cotton, are known to attack oats, rye, cowpeas, crab grass, and Johnson grass. Sweet potatoes, peanuts, tobacco, watermelons, and the roots of a wild bamboo are also among the food plants of this wireworm. The adults have been observed feeding on stems of cowpeas and on young, tender leaves of corn and crab grass.

CHARACTER OF THE INJURY.

Corn plants infested by this wireworm become wilted and stunted, with leaves of a bluish shade, brown at the tips, which stand out from the stalks stiffly instead of bending over gracefully as in a healthy plant. Deprived of most of the roots through the work of the larvæ of this wireworm, the plant can be pulled up with little effort. Weak plants soon succumb, leaving gaps in the rows, but the more vigorous plants put forth new roots in abnormal numbers. These are matted together and distorted, and although the plants survive, only "nubbins" are produced. The infestation is not confined to the impoverished areas, for there may be larvæ among the roots of tall and apparently healthy plants. Rolling land infested by this insect presents a patchy appearance, the sandy knolls standing out distinct and bare, although overgrown later with weeds, particularly crab grass, briars, and morning-glories. For a long time there was a theory among farmers that lightning caused the injury to corn which is now rightly attributed to this wireworm.

In the case of cowpeas, the fibrous roots suffer most, the thicker roots being perforated, so that the plants become yellow and dwarfed, and fail to vine.

Cotton is injured in the early stages by larvæ boring into the seed and injuring the very young plants, checking the growth so much that the plant dies or struggles along only to produce little or no cotton.

LIFE HISTORY OF THE SPECIES.

Beetles of the corn and cotton wireworm (fig. 1, *a*) are abroad in the fields from early June until the last of August. The eggs (fig. 2), which are laid in groups of from 3 to 20 in the soil about the roots of corn, cowpeas, and other food plants, are deposited, for the most part, during late June and July. These hatch in from 8 to 11 days into the young wireworms or larvae (fig. 1, *b*) which immediately commence feeding upon the roots. The exact duration of the period of development in the soil has not yet been determined, but the information now at hand indicates that the species lives in the larval stage for two years and possibly three. It is true that adults are to be found each year, but this is probably due to overlapping broods. During May or June each full-grown larva constructs a small earthen cell in the soil and in this it changes to a pupa (fig. 3). The pupal stage averages 12 days in length and during this time the pupa is almost motionless and takes no food. After this it transforms to the adult or beetle. As is usually the case, the duration of the egg and pupal stages varies with temperature and moisture conditions.

HABITS OF THE LARVÆ, OR WIREWORMS.

The larvae, or wireworms, feed upon the roots of their food plants throughout the summer months and up to about the first of October, and during this time are found within 18 inches of the surface of the ground, the depth depending upon the moisture content of the top soil. During a hot, dry spell the wireworms remain from 12 to 18 inches below the surface, but after a rain they can be found within 2 inches of the surface.

With the approach of cold weather they begin a general downward movement, which accounts for the farmer's inability to locate them during the late fall and winter months. At Charleston, Mo., December 1, 1914, they were found in the sand at the remarkable depth of 5 feet. This appeared to be the average depth at which they remained during the winter in this locality, observations showing the depth to vary from 4 to 6 feet. From these facts it will be seen that fall or winter plowing would be useless as a control or remedial measure.

By the last of February in some localities, or as soon as winter breaks up, the larvae gradually make their way to within 2 to 3 feet of the surface. By the middle of April they are numerous within 6 inches of the surface of the ground. From the time the larvae travel downward in the fall until they return to the top soil they eat practically nothing. In laboratory experiments, larvae remained alive and healthy in cages of moist pure sand, without organic food, for six months.

The larvæ are quick of movement and wriggle vigorously when disturbed. In indoor rearing cages they are found to be keenly susceptible to an overabundance of moisture, and, too, will die if the cage soil is allowed to get excessively dry.

Cannibalism is common among them, especially under artificial rearing conditions, but the fact that as many as 106 larvæ have been found in one hill of corn is evidence that this habit does not exist to any great extent in the field when there is plenty of plant food at hand.

HABITS OF THE ADULTS, OR BEETLES.

The adults, or beetles, are also very quick of movement. Immediately upon being disturbed they "snap" themselves and fall to the ground from the leaf or stem upon which they are resting. On the ground they feign death for a few moments, then quickly scamper off to a hiding place. The adults feed very little, hence any injury which they might cause would be hardly perceptible.

They evidently fly well, as they have been collected in quantities around lights at night. This would probably explain the fact that adults have been collected several miles from the nearest sandy spot or field. The author, however, has never seen them fly in the daytime.

The female beetles will not deposit eggs in soil which is crusted over or baked, but leave such a field and search for one which is covered by a dust mulch, or which has recently been plowed. This fact is important and should be taken into account when control measures are being considered, since cultivation at the time the beetles are most numerous means that excellent conditions are given the females for depositing their eggs.

NATURAL ENEMIES.

Comparatively few natural enemies of this wireworm have been noted. No internal parasites have been reared from any stage of the species. Birds feed upon all kinds of wireworms including those of the genus *Horistonotus*.

INEFFECTUAL REMEDIAL MEASURES.

PLOWING.

Late fall and winter plowing as a method of reducing the numbers of the pest by turning up and exposing the larvæ to the elements is of no value, as the wireworms are at this time at such depths in the soil that they would not be disturbed by the plowing. Plowing or cultivating for this purpose at other times of the year is of little avail as the wireworms are so quick of movement that almost as soon

as exposed they are again hidden in the loosened soil. Even chickens or turkeys are not sufficiently alert to catch many.

TRAPPING ADULT BEETLES.

Trapping the beetles at night by means of strong lights above open vessels containing water or kerosene would in no way prove practical, especially on a large scale.

POISONING.

Killing the wireworms by placing poisoned baits in the soil around the hills of corn is not practical, nor will the treating of seeds with poisons or repellents assist in protecting the plants from wireworm attacks. Turning under wood ashes, as a remedy against wireworms, has proved to be of no avail.

EFFECTIVE CONTROL AND REMEDIAL MEASURES.

The following control measures are formulated from the study of the habits of the insect, and are based on results of such measures carried on over a period of two years. It must be remembered that as this species has been under investigation for only three years, the following remedial measures are subject to more or less modification.

HASTENING EARLY PLANT GROWTH.

The most important factor in reducing injury by this wireworm is the employment of methods which hasten early plant growth in the spring, the object of stimulating growth being to enable the plants the better to withstand the attacks of the wireworms. In the case of corn this consists of early planting—at least by April 20 for southeastern Missouri and northeastern Arkansas—followed by frequent cultivation until the middle of June.

CROP ROTATION.

Any system of crop rotation after harvesting the corn may be carried out, and a winter cover crop such as wheat or rye is advised. Pasturing this during winter months and turning it under in the spring is very beneficial, since humus is thus added and the sandy soil is thereby stiffened. An infested field should not be planted to corn two years in succession.

If a catch crop of red clover can be obtained it is an excellent one to come in the rotation for two or three years. Such combinations as wheat and clover are to be recommended for southeastern Missouri, as they not only afford two crops a year from the

same field, but also permit the soil to remain undisturbed during the period when the female beetles are laying their eggs. As stated elsewhere in this bulletin, the females prefer loose soil for egg deposition, especially soil which has been recently cultivated or plowed.

A system of handling the ground and crops so that the soil will not be disturbed from the middle of June until the middle of August is one of great importance, and it may prove to be the most beneficial step in eradicating the wireworms from an infested area. This may be brought about by omitting from the rotation such crops as would normally require summer cultivation.

The supposition that an infestation of the corn and cotton wireworm is worse following cowpeas seems to be unfounded.

MANURING.

The manuring of infested areas has long been recommended as the best control measure. The theory was advanced, especially by some farmers, that the manure turned under is actually distasteful to the larvæ and kills them outright. Although this is not the case, nevertheless the turning under of manure and cover crops has the effect of adding humus to the top soil; and, as it is known that the larvæ can not long survive except in sandy soils, it is well to spread as much manure as possible on infested areas and to turn it under.

LAND RESTING.

If it were practicable to allow the infested fields to lie idle, or "lay out," as it is termed, for a period of three years, this would no doubt prove the most effective means of getting rid of the pest, since by leaving the ground undisturbed a crust would be formed on the surface through which the majority of adult wireworms could not emerge. It would also serve to prevent the few emerging adults, as well as those flying in from other fields, from entering the soil for egg deposition. However, this practice naturally will not often appeal to the farmer.

SUMMARY OF CONTROL MEASURES.

- (1) Plant infested fields to such crops as do not require summer cultivation, such as clover, cowpeas, soy beans, or grasses.
- (2) Add humus to the light sandy spots by turning under manure and cover crops.
- (3) If grain crops be planted, allow stubble to remain until the middle of August.
- (4) If corn must be grown, plant early and do everything possible to hasten rapid growth. Do not plant corn two years in succession.

PUBLICATIONS OF U. S. DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS.

AVAILABLE FOR FREE DISTRIBUTION.

Cotton Bollworm. (Farmers' Bulletin 200.)
Common White Grubs. (Farmers' Bulletin 543.)
The Chalcids-fly in Alfalfa Seed. (Farmers' Bulletin 636.)
The Grasshopper Problem and Alfalfa Culture. (Farmers' Bulletin 637.)
The Hessian Fly. (Farmers' Bulletin 640.)
Alfalfa Attacked by the Clover-root Curculio. (Farmers' Bulletin 649.)
The Chinese Bug. (Farmers' Bulletin 657.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
The True Army Worm and Its Control. (Farmers' Bulletin 731.)
The Hessian Fly Situation in 1915. (Office of Secretary Circular 51.)
The Spring Grain Aphids or "Green Bug" in the Southwest and the Possibilities of an Outbreak in 1916. (Office of the Secretary Circular 55.)
Southern Corn Rootworm, or Budworm. (Department Bulletin 5.)
Western Corn Rootworm. (Department Bulletin 8.)
The Oat Aphid. (Department Bulletin 112.)
The Alfalfa Caterpillar. (Department Bulletin 121.)
Clover Mite. (Entomology Circular 158.)
Clover-root Curculio. (Entomology Bulletin 85, pt. 111.)
Maize Billbug. (Entomology Bulletin 95, pt. 11.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS.

The Larger Corn Stalk-borer. (Farmers' Bulletin 634.) Price, 5 cents.
The Southern Corn Leaf-Beetle. (Department Bulletin 221.) Price, 5 cents.
The Shorthorned Grain Leafhopper. (Department Bulletin 254.) Price, 5 cents.
The Pea Aphid with Relation to Forage Crops. (Department Bulletin 276.) Price, 15 cents.
Joint-worm. (Entomology Circular 66.) Price, 5 cents.
Some Insects Affecting Production of Red Clover Seed. (Entomology Circular 69.) Price, 5 cents.
Wheat Strawworm. (Entomology Circular 106.) Price, 5 cents.
Western Grass-stem Sawfly. (Entomology Circular 117.) Price, 5 cents.
Clover Root-borer. (Entomology Circular 119.) Price, 5 cents.
Alfalfa Gall Midge. (Entomology Circular 147.) Price, 5 cents.
Lesser Clover-leaf Weevil. (Entomology Bulletin 85, pt. I.) Price, 5 cents.
Sorghum Midge. (Entomology Bulletin 85, pt. IV.) Price, 10 cents.
New Mexico Range Caterpillar. (Entomology Bulletin 85, pt. V.) Price, 10 cents.
Contributions to Knowledge of Corn Root-aphids. (Entomology Bulletin 85, pt. VI.) Price, 5 cents.
So-called "Carlew Bug." (Entomology Bulletin 95, pt. IV.) Price, 10 cents.
False Wireworms of Pacific Northwest. (Entomology Bulletin 95, pt. V.) Price, 5 cents.
Alfalfa Looper. (Entomology Bulletin 95, pt. VII.) Price, 5 cents.
Leafhoppers Affecting Cereals, Grasses, and Forage Crops. (Entomology Bulletin 108.) Price, 20 cents.
Spring Grain-aphids or Green Bug. (Entomology Bulletin 110.) Price, 25 cents.
Preliminary Report on Alfalfa Weevil. (Entomology Bulletin 112.) Price, 15 cents.